



Instituto de Energía Eléctrica  
Universidad Nacional de San Juan

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# Santiago 2013 Symposium on Microgrids

Santiago de Chile, September 11th & 12th, 2013

## Battery Model for Microgrid Studies

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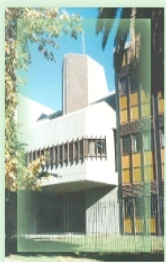
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# Instituto de Energía Eléctrica



- Universidad Nacional de San Juan
- Facultad de Ingeniería
- Instituto de Energía Eléctrica (IEE)



# ***Instituto de Energía Eléctrica***

## **Main Activities at IEE**

- **Undergraduate and graduate teaching**
- **Human resource training**
- **Consulting and technology transferances**
- **Research and technology development**



# ***Instituto de Energía Eléctrica***

## **Undergraduate and graduate teaching:**

- Electrical Engineering Career
- Doctorate and Master program  
in Electrical Engineering
- Intelligent Power System Master program  
(forthcoming)

## **Professional Staff**

- 41 teachers and researchers
- 46 doctoral candidates
- 10 undergraduate teaching assistants



# ***Instituto de Energía Eléctrica***

## Areas of Research and Development:

- Electricity Markets
- Performance analysis of Power Systems.  
Steady state and dynamic studies
- Design and testing of electrical equipment  
and laboratories. High voltage laboratory.
- Power electronics and electrical drives.  
Control of alternative energy sources and  
energy storage.

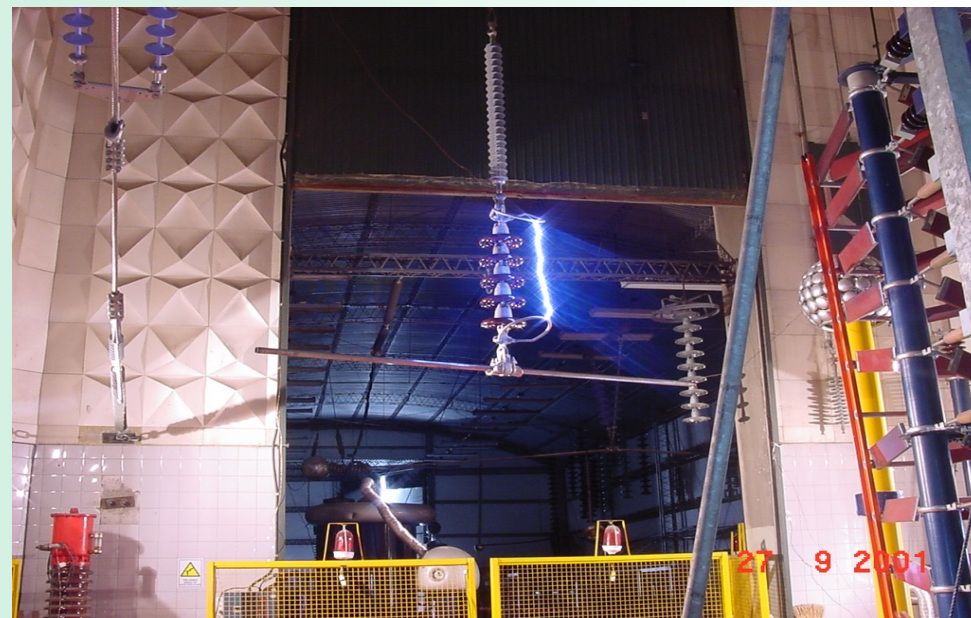




# ***Instituto de Energía Eléctrica***

## **Building and Laboratories**

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## **New H. Voltage and Renewable Energy Lab**

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# ***Instituto de Energía Eléctrica***

## **Renewable Energy Laboratory (SEPEA)**

- Weather Station
- PV Peak Power Meter
- PV Power Inverter (SMA)
- Data acquisition system (“Sunny Webbox”)
- 6x50W and 15x80W PV modules
- Wind Turbine (500W)
- Ultracapacitor



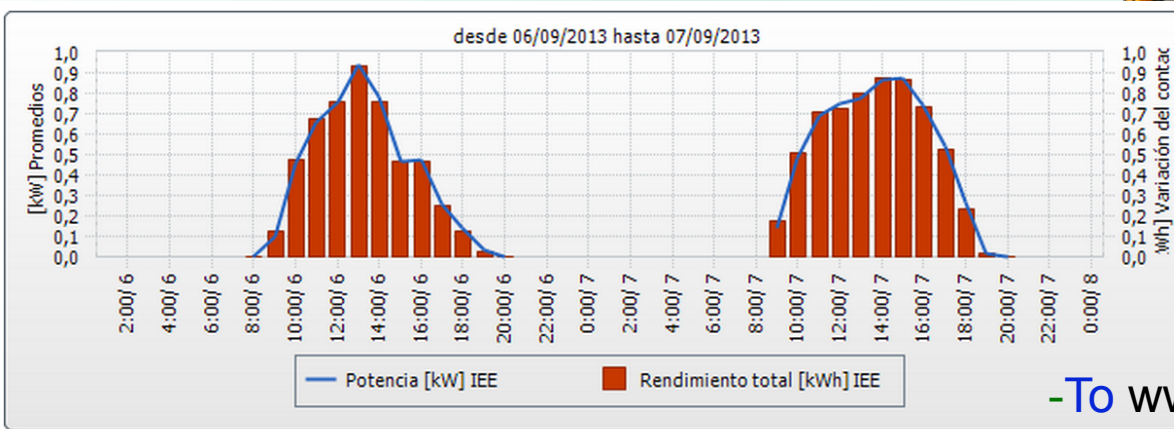
# Instituto de Energía Eléctrica

## Renewable Energy Laboratory (SEPEA)



15x80Wp SolarTec PV Modules

- Power inverter: to 220Volts
- Sunny Webbox: to IEE LAN



- To [www.SunnyPortal.com](http://www.SunnyPortal.com)



# ***Instituto de Energía Eléctrica***

## **Renewable Energy Laboratory (SEPEA)**

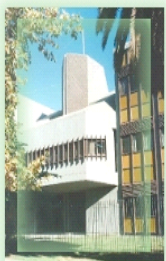
### **Hail stone Test**



**PV Modules for San Juan I  
1,2 MWp PV field**

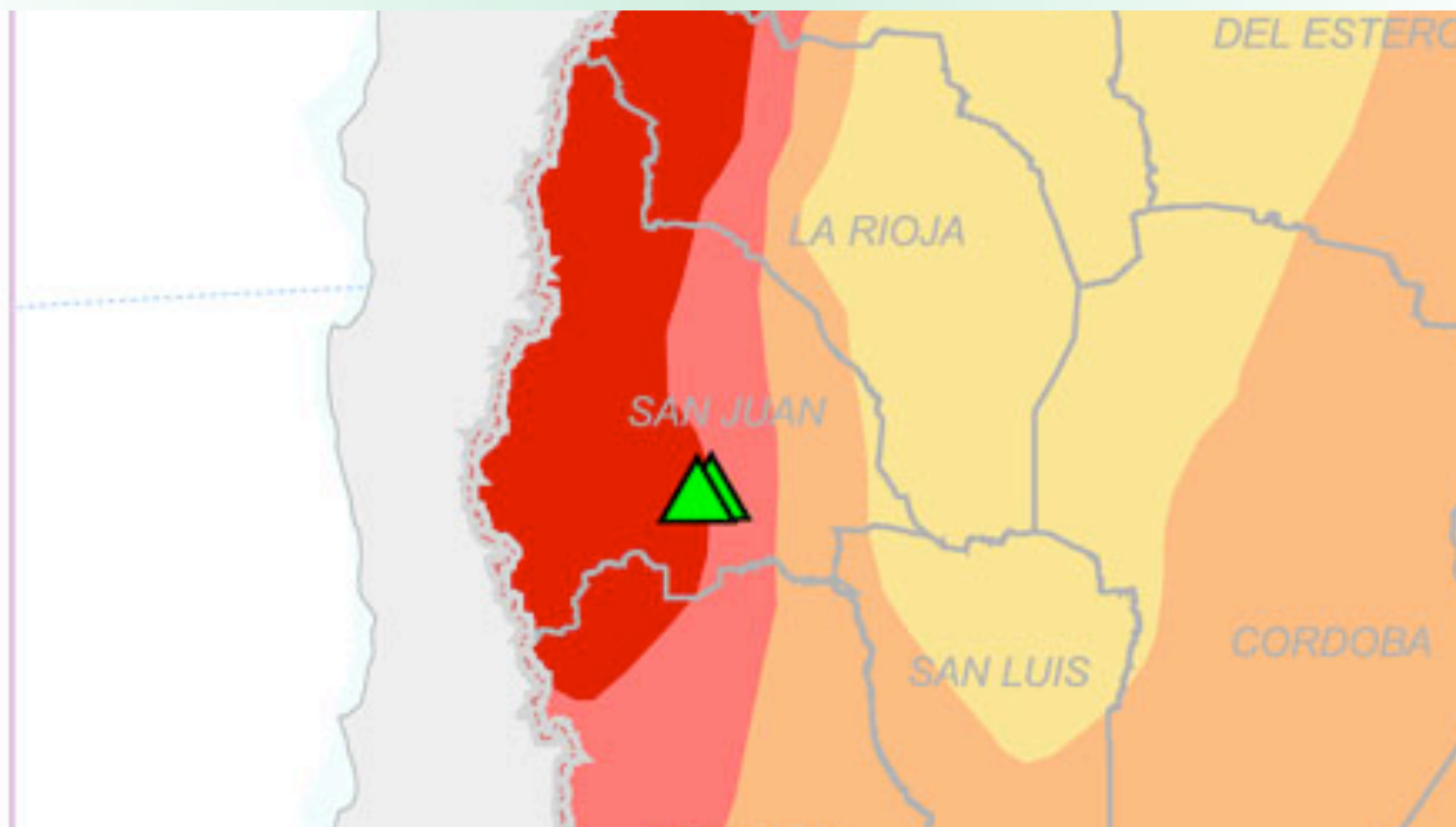






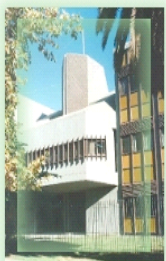
# ***Renewable Resources in Argentina***

## **Solar radiation in San Juan**



San Juan I (1,2 MWp) and Cañada Honda (5MWp to 20 MWp) PV fields





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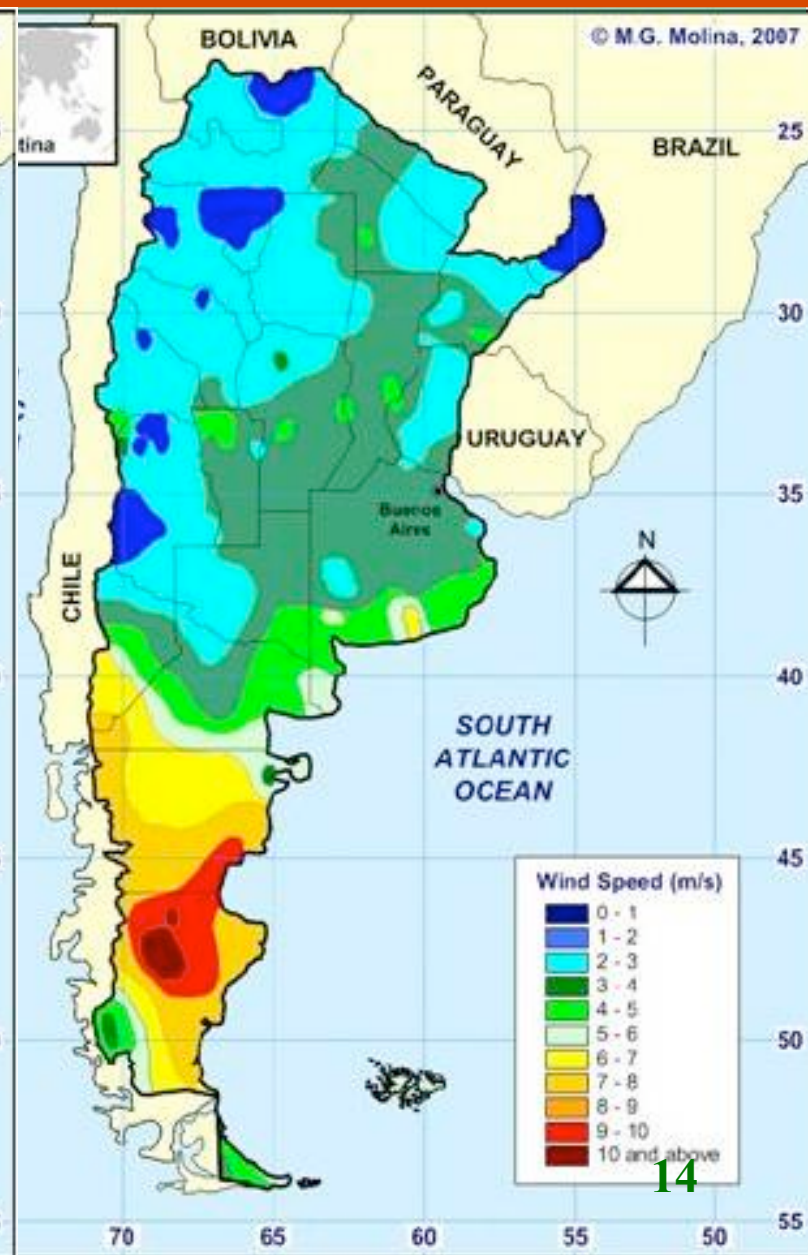
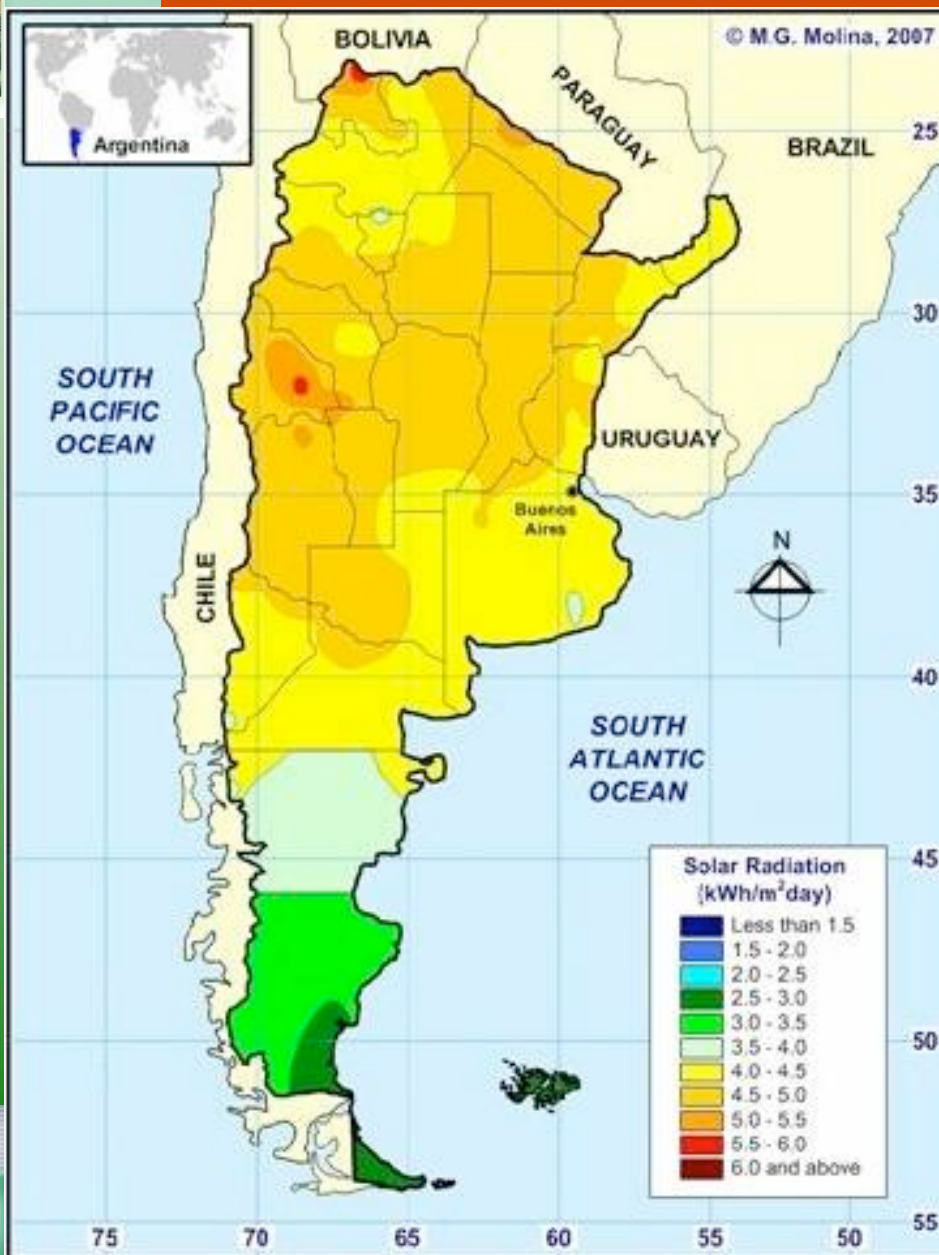
# ***Renewable Resources in Argentina***



San Juan I (1,2 MWp) PV field



# Renewable Resources in Argentina







# ***Microgrids***

## **Conventional Power utilities**

- **Use non-renewable energy sources**
- **Environmental hazards**
- Well-known technologies
- Low specific building costs
- **Ease resources availability and storage:**
  - *back-up capacities help maintain spinning reserve*



# ***Microgrids***

## **Microgrids**

- **Use sustainable energy resource:**  
Mainly uses Solar and Wind energy  
- plentiful availability
- **Reduce environmental impacts**
- **Can operate isolated from the main power grid**

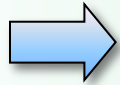
## **Major drawbacks of using wind and solar:**

- **Unpredictability of generated power**
- **Constrained back-up capacities**
- **No spinning reserve contribution**





# ***Microgrids***



**Load Management and Energy Storage  
should be used in Microgrids**

**Batteries can storage energy from renewable  
energy sources to collaborate in spinning  
reserve and back-up capacities**

**Batteries can provide: Power Quality (PQ) and  
Peak Saving (PS) support**

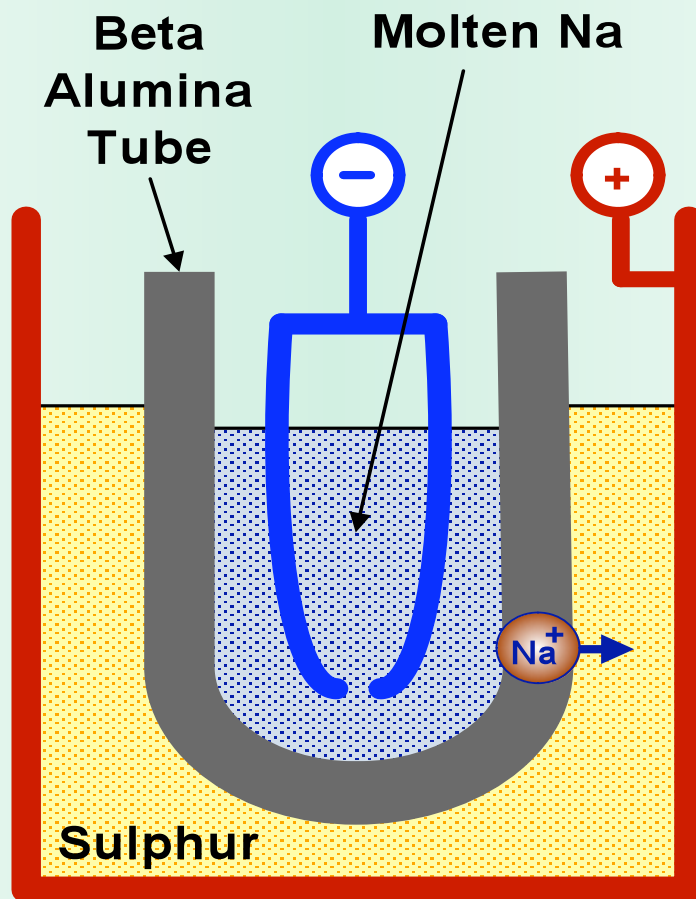
**Objective:**

**“Model a battery for PQ and PS purpose”**



# ***Electrochemical batteries***

## **NAS Battery**



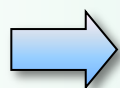
Schematic model of a sodium-sulphur battery



# ***Electrochemical batteries***

## **NAS Battery**

- TEPCO and NGK developed the first commercial sodium-sulphur battery (NAS®, registered in Japan) to replace pumped hydro energy storage
- High power density
- High energy density (three times Lead Acid)
- Can be used for peak saving (PS) or power quality (PQ) purposes
- A NAS battery module of 50kW can discharge at up to 250kW for 30 seconds.

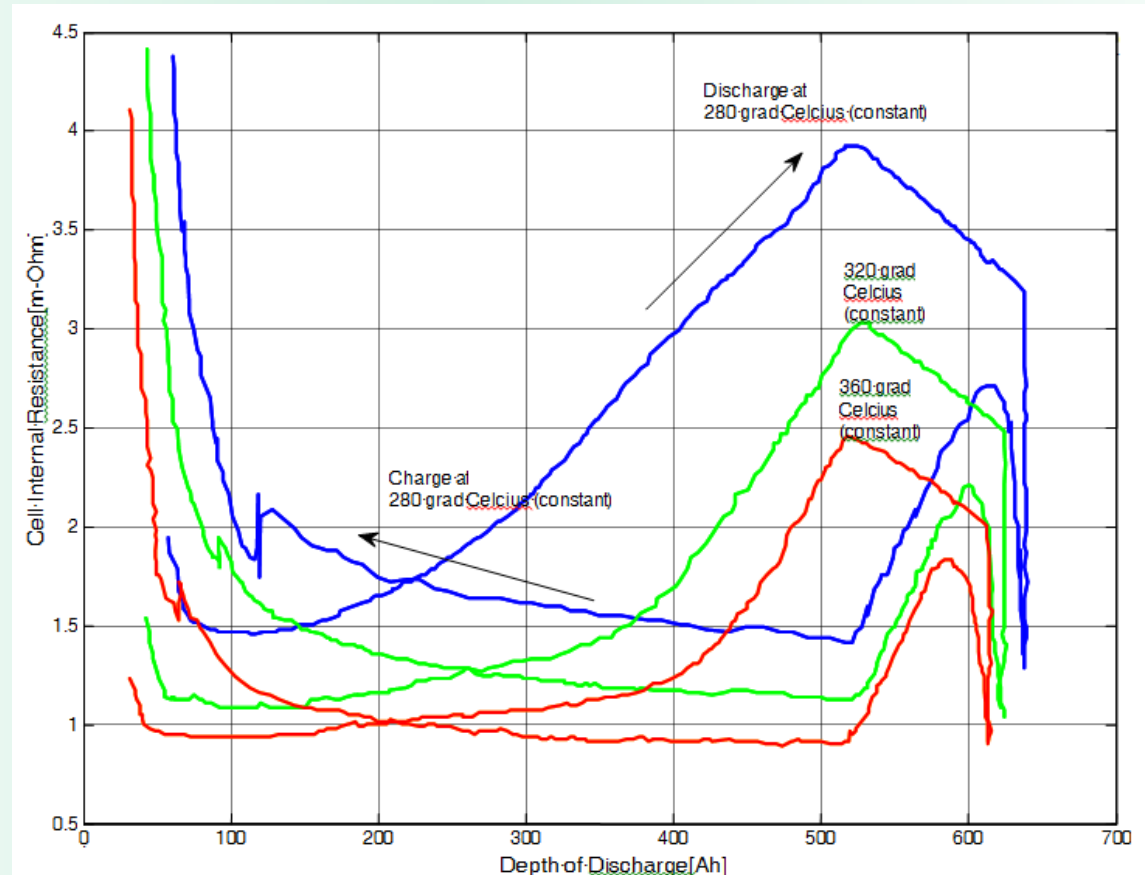


**The battery open circuit voltage ( $V_{oc}$ ) and the internal resistance depends on the depth and direction of discharge (SOD), in a non-linear way**



# Electrochemical batteries

## NAS Battery



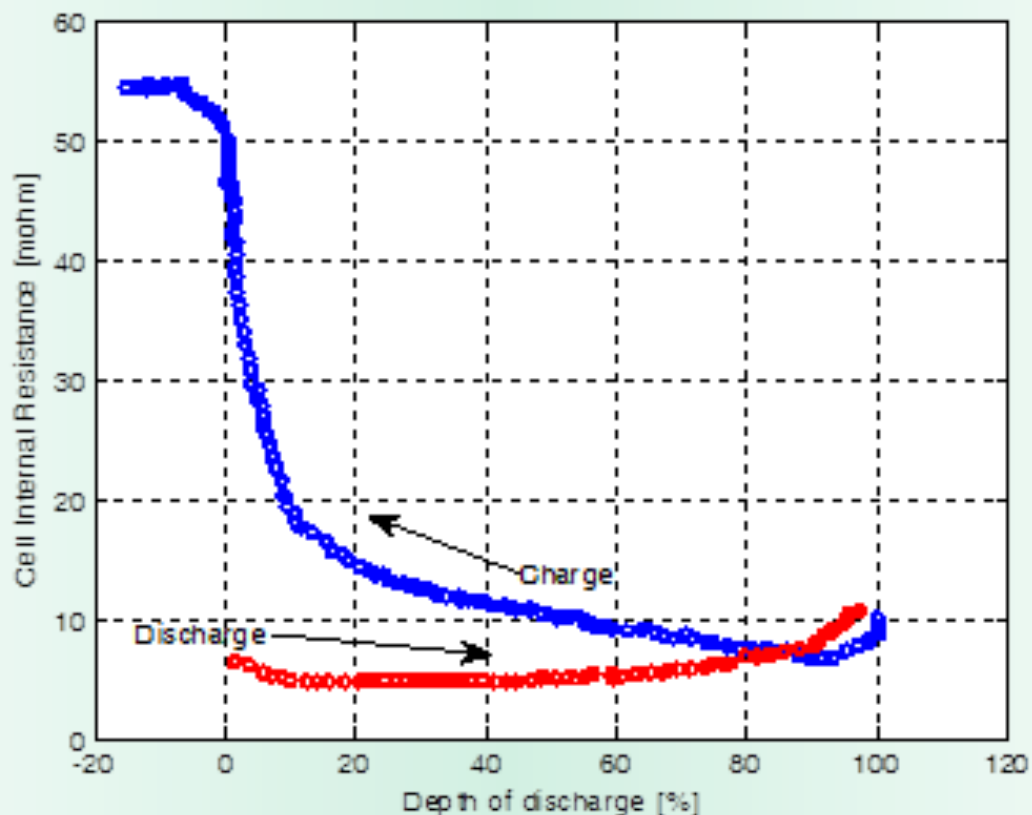
Internal resistance variation depending on the state of charge/discharge for various temperatures in a NAS-type battery cell (Hussien 2007)





# Electrochemical batteries

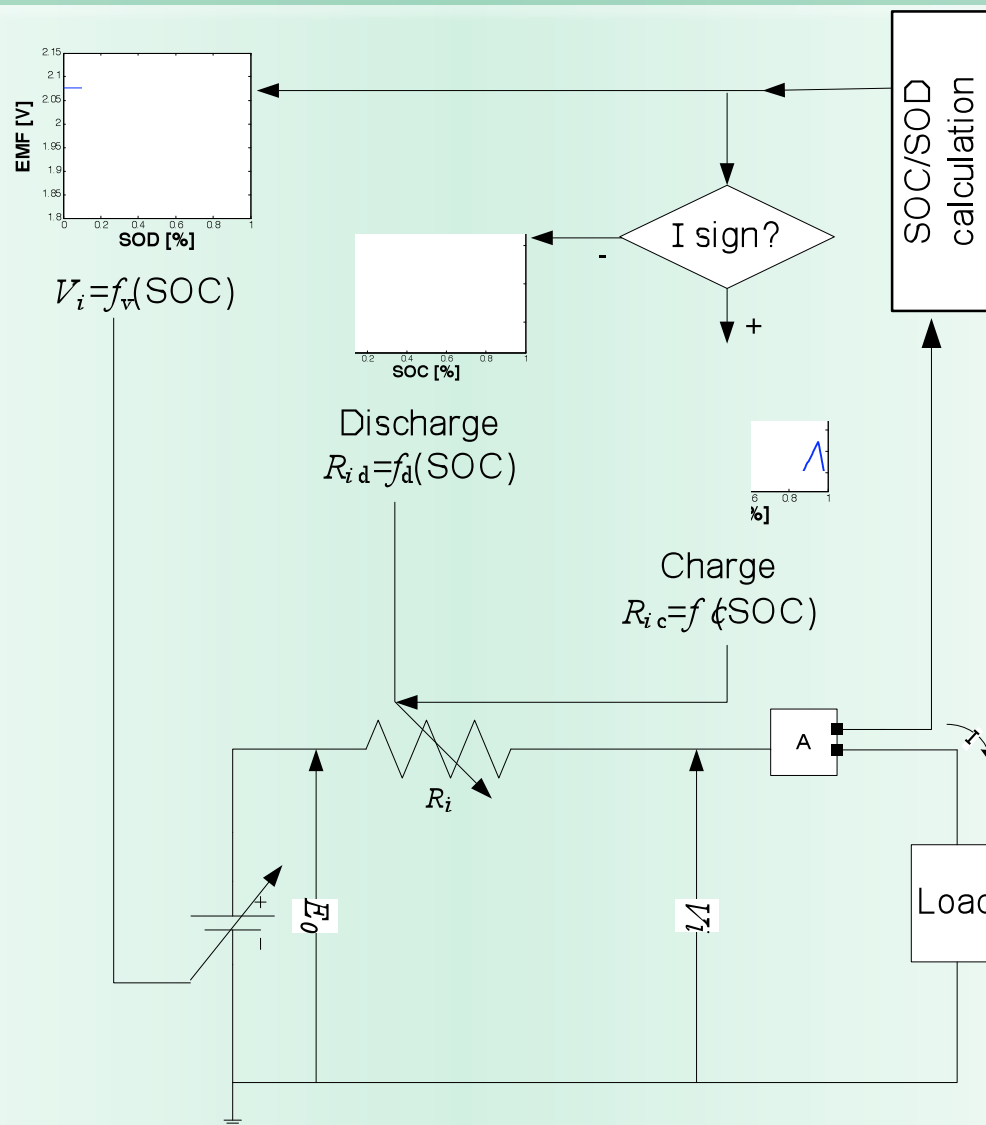
## Pb-Acid Batteries



Internal resistance in charging or discharging state as a function of SOD for a Pb-acid battery at 25°C (CIEMAT 1992)



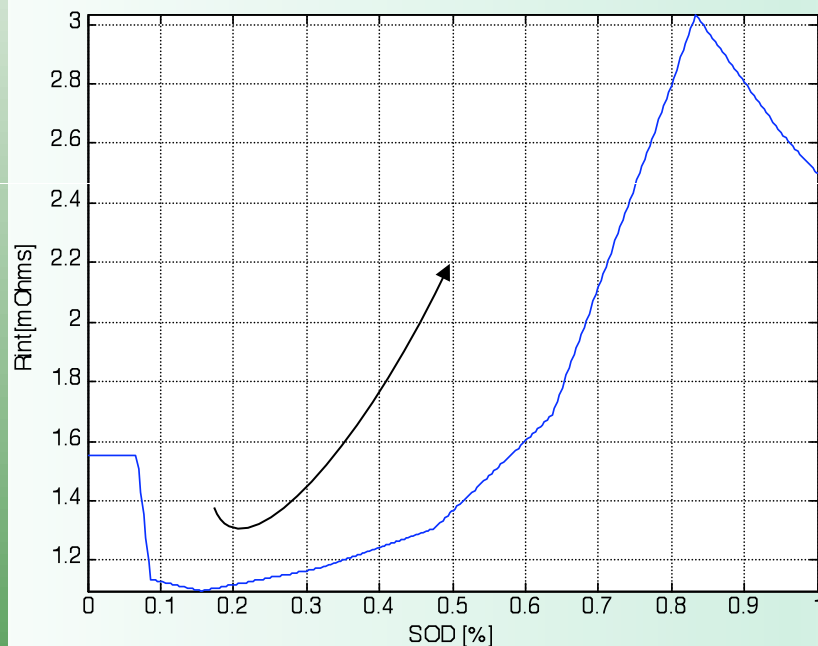
# General battery model



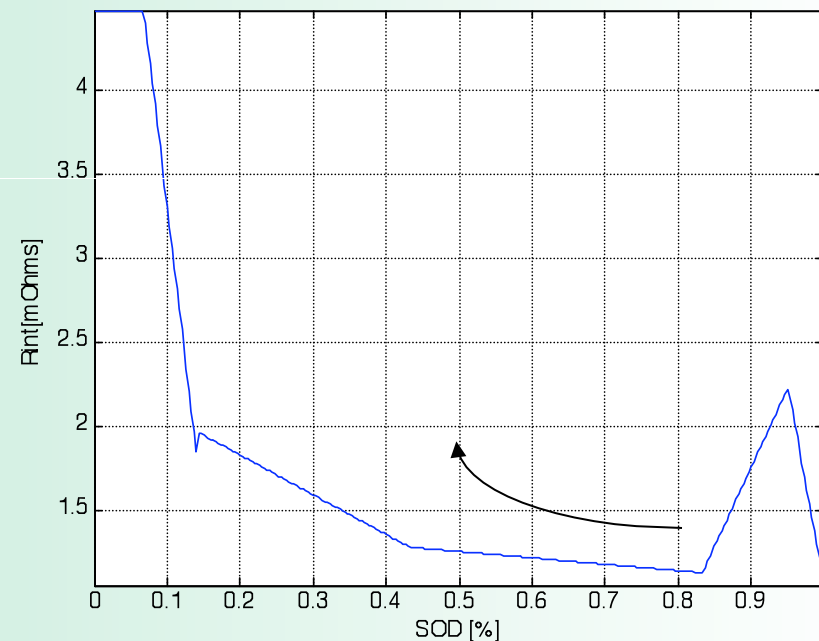
Proposed general model of the Battery Storage Systems for MGs 22



# Battery Model Test



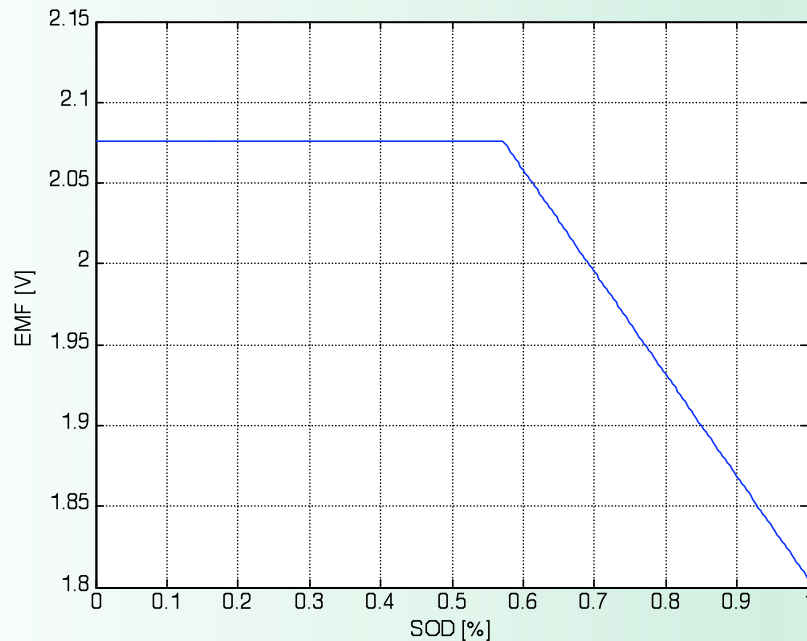
Internal cell resistance vs. SOD  
at 320°C for discharge  
(Simulated)



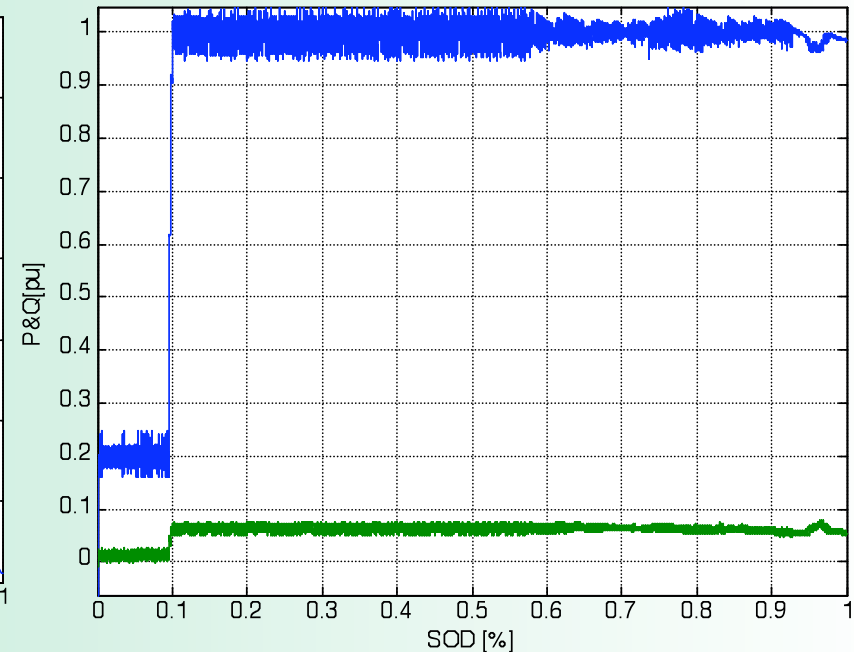
Internal cell resistance vs. SOD  
at 320°C for charge  
(Simulated)



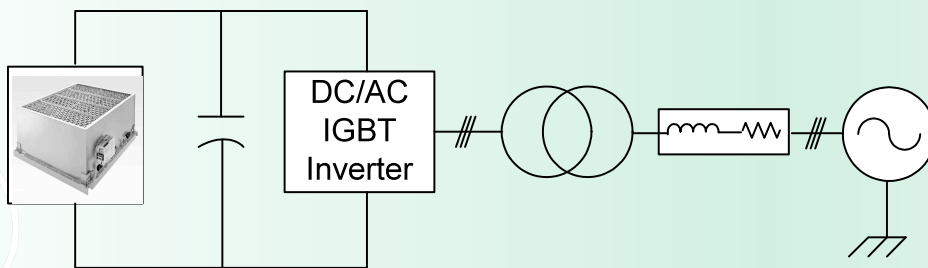
# Battery Model Test



Cell Voc vs. SOD  
(Simulated)



Variation of P and Q power  
from the Battery module (AC side)



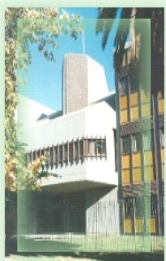
NAS module connected  
to a testing power system





## ***Final Remarks***

- ➡ Sodium–sulphur battery presents advantageous opportunities for energy storage in power systems. Are much smaller and lighter than other classical batteries and they have neither memory effects nor toxic materials.
- ➡ Authors have developed a new NAS model suitable to study the insertion of NAS batteries modules into MGs.
- ➡ Dynamic system simulation studies demonstrate the effectiveness of the developed model that can be used for other batteries types



More information on the Instituto de Energía Eléctrica at:  
[www.iee-unsj.org](http://www.iee-unsj.org)

Further information about the battery model can be found  
in the Chapter 12. of the book "Energy Storage  
Technologies and Applications" at:  
[www.intechopen.com](http://www.intechopen.com) - <http://dx.doi.org/10.5772/52219>

***Thanks for your attention!***

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